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ORIGINAL PAPER

Diversity and regeneration status of Sarkot Van Panchyat in Garhwal Himalaya, India

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Abstract: We investigated the floristic composition, phytosociological and regeneration status of Sarkot Van Panchyat (community forest) in Chamoli district of Garhwal Himalaya. A total of 52 plant species of 46 genera and 26 families were recorded, which included 12 trees, 18 shrubs and 22 herb species. *Quercus leucotrichophora* was dominant tree species in sapling and seedling layers, followed by *Lyonia ovalifolia* and *Rhododendron arboreum*. Out of 12 tree species, 7 species in seedling stage and 8 species in sapling stage were recorded in the study area. The 44.41% species in the study area showed good regeneration status, 16.66% species were fairly regenerating, and 8.33% species showed poor regeneration status, while 33% species were not regenerating. Number of individuals from lower girth classes (0-10 cm and 10-30 cm) showed decreasing trend with the increase in size of girth class. Shannon index (H) for trees, shrubs and herbs was recorded as 1.82, 2.24 and 2.41 respectively. Simpsons index (C_D) was recorded as 0.21, 0.12 and 0.12 for trees, shrubs and herbs respectively. The forest should be divided into compartments for better management purpose and each compartment should be closed for five years to assist regeneration and enrichment planting may also be carried out for sustainable management.

Keywords: traditional forests; regeneration; dominant; Garhwal Himalaya; composition

Introduction

Indigenous and Community Conserved Areas (ICCAs) are natural and/or modified ecosystems with biodiversity values, ecological services and cultural values, voluntarily conserved by indigenous and other communities through local or customary laws (Berkes 2008). The history of Forest Panchyats in Central Himalayan region of India dates back to early 19th century. After the defeat of Ghurkhas in 1815, the British occupation of the central Himalaya was complete. Van Panchyats in Central Himalaya hills were born out of conflicts and compromises that followed the settlements and reservation of forests in the hills at the turn of the nineteen century. Till 1865, people had unrestricted rights in the use of forest resources except as and when some forest produce was to be exported (Atkinson 1882). The people's agitation and protests forced government to form committee, named Kumaon Forest grievances Committee in 1922 to look in to the demand of people related to forest problems (Pant 1922). The committee recommended reclassification of forest and formulation of Van Panchyats to manage the forests in areas where local demand was high. This empowered villagers to form relatively autonomous (at local level) management committees, Van Panchyat Committees for hill forests. In Uttarakhand, 65% geographical area is under the forest area, of which about 15% forest area is under Van Panchyat and is the second largest in vegetation area after reserve forest. During the last few decades of 20th century, growing environmental problems increased exponentially due to human influence on the earth's natural resources, leading to rapid extinction of biodiversity (Wilson 1985; Hannah et al. 1995).

Regeneration is a key process for the existence of species in the community and is also a critical part of forest management, because it can help forests to maintain the desired species composition. The tree regeneration can be predicted by the structure of their populations. The presence of sufficient numbers of seedlings, saplings and young trees in a given population indicates that the forest species are able to successfully regenerate (Khan et al. 1987b). The presence of older tree is better for establishing young seedlings as they provide shade and microclimate (Taylor et al. 1988). The seedlings, saplings, and young trees make greater contribution to the total population in successful regeneration (Khan

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et al. 1987a). The future community structure and regeneration potential of the species could be predicted from the relative proportion of seedlings and saplings in various species in the forest. Natural regeneration and establishment of primary forest species are the crucial for most of species (Primack et al. 1992). In general, regeneration status of species is affected by anthropogenic factors (Barik et al. 1996). The present study was therefore, carried out in Sarkot Van Panchyat to assess its floral wealth, phytosociological and regeneration status.

Materials and methods

Location and climate

The study area, Sarkot Van Panchyat (Sarkot Community Conserved Forest Area) is located in Gairsen block of district Chamoli in Garhwal Himalaya of Uttarakhand, India. The altitude of the site ranges from 1,950 m to 2,250 m with 30º05'08.3"–30º 05'43.9" N to 79º14' 05.8"–079º14'50" E. The people around the study area are basically agro-pastoralists. The climate of the area is monsoonic, which is divisible into summer, rainy and winter. This area receives heavy rainfall during rainy season.

Methodology

The phytosociological analysis of tree, sapling and seedling layers was carried out by randomly laying down 25 quadrats of 10 m × 10 m size. For studying the shrubs and herbs, two quadrats of 5 m × 5 m and four of 1m × 1m within 10 m × 10 m were laid respectively. About 5% of total forest area was sampled, of which 0.1% area was enumerated. The size and number of samples were determined according to the methods of Saxena and Singh (1982). The vegetation data were quantitively analyzed for abundance, density and frequency (Curtis et al. 1950). The Important Value Index (IVI) for all the layers of vegetation was determined as the sum of relative frequency, relative density and relative dominance. The distribution pattern of different species was studied using the ratio of abundance to frequency (Curtis et al. 1956). The index of general diversity was computed by using Shannon-Wiener information (H'), (Shannon-Wiener 1963). The concentration of dominance (C_D) was measured by Simpson's index (Simpson 1949). The book of published flora (Gaur 1999) was used for the identification of plant species, and taxonomists were also consulted for the identification and comparison of the specimen.

For regeneration, in each quadrat of 10 m ×10 m, individuals having >31.5 cm CBH (circumference at breast height *i.e.* 1.37 m above the ground) were considered as trees, which were measured individually. Individuals having <10.4 cm CBH were considered as seedlings and individuals having CBH from 10.5 cm to 31.5 cm were considered as saplings (Knight 1963). The density of seedlings and saplings is considered as an indicator of the regeneration potential. The criteria for regeneration status in the present study were based on the number of seedlings and saplings of individual tree species. The regeneration status of the sampled species was based on phytosociological data **(**Uma Shankar 2001**)** in the following categories:

(1) Good regeneration, number of seedlings> saplings >adults.

(2) Fair regeneration, number of seedlings >or ≤ saplings ≤ adults.

(3) Poor regeneration, if the species survive only at sapling stage, there are no seedlings (Number of saplings may be more, less or equal that of adults).

(4) No regeneration, individuals of species are present only in adult form.

(5) New regeneration, individuals of species have no adults but they show only seedlings or saplings.

Results and discussion

The structure and function of forest ecosystem is determined by the plant component in the system (Richards 1996). A total of 52 species of 46 genera and 26 families were recorded in this study area, of which 12 species were trees, 18 shrubs and 22 herbs. Rosaceae was dominant family with 8 species, followed by Asteraceae and Poaceae with 6 and 5 species respectively (Table 1–3). The study area was dominated by tree species like *Quercus leucotrichophora*, *Rhododendron arboreum*, *Myrica esculenta*, *Lyonia ovalifolia* and *Alnus nepalensis*. In shrub layer, the dominant species were *Berberis aristata*, *Debregeaia longifolia*, *Eupatorium adenophorum*, *Colebrookia oppositifolia* and *Pyracantha crenulata* whereas dominant herbs were *Andropogon munroi*, *Cymbopogon martinii*, *Cynodon dactylon*, *Themeda arundinacea and Drypteris cochleata.*

Importance Value Index (IVI) is the most important parameter to understand the community organisation in relation to competitive ability of dominant species. *Quercus leucotrichophora* was dominant tree species having highest value for IVI (103.54), followed by L*yonia ovalifolia* with IVI (58.78). The maximum values for frequency (88%), density (420 individuals· ha^{-1}) and abundance (4.77) were also recorded for *Quercus leucotrichophora*, followed by *Rhododendron arboreum* with frequency (68%), density (272 individuals· ha^{-1}) and abundance (4.00). *Prunus cerosoides* was recorded as least dominant species in tree layer with lowest value for IVI (1.40), density (4 individuals· ha^{-1}), abundance (1.0) and frequency (4%). Total basal cover values recorded were in the range of 0.07 m^2· ha^{-1} to 21.80 m^2· ha^{-1}. *Quercus leucotrichophora* had the highest value of total basal cover (21.80 m^2· ha^{-1}), followed by *Lyonia ovalifolia* (11.23 m^2· ha^{-1}). Rawat (2005) also reported total basal cover values from 3.74 m^2· ha^{-1} to 80.36 m^2· ha^{-1} for temperate forests in Garhwal Himalaya. Kumar et al. (2005) recorded total basal cover values from 14.3 m^2· ha^{-1} to 24.8 m^2· ha^{-1} in Garhwal Himalayan forests. Distribution pattern of most species in the present study was found to be contagious. Several researchers (Greig-Smith 1957; Singh et al. 1974) reported that the distribution pattern of most species was contagious in natural vegetation. Kumar et al. (2004, 2005) also reported that dis-

tribution pattern of most species was contagious for different sub-tropical forests in Garhwal Himalaya. The total density and TBC (total basal cover) values were 1.224 individuals· ha^{-1} and 55.92 m^{2}· ha^{-1} respectively (Table 1). Shannon index (H') was 1.82 whereas Simpsons index (C_D) was 0.21 in the present study for tree species. Present value for Shannon Index (1.82) is also supported by (Shannon Index values from 1.6 to 2.6) from previous studies of sub-tropical forests in Garhwal Himalaya (Kumar et al. 2010). Rikhari et al (1991) reported that species diversity across different forest types ranged from 0.22 to 2.76. The species diversity of some Panchyat forest ranged from 1.96 to 3.55 (Negi et al. 2008). The low diversity value in the present study might be due to anthropogenic pressure. This forest is dominated by *Quercus leucotrichophora*, which is most utilized species for fodder and small timber by villagers.

Table 1. Phytosociological analysis of trees

Name of trees	Family	F%	Density (individuals· ha^{-1})	Ab	TBC	A/F	IVI
Alnus nepalensis (D.Don)	Betulaceae	16	52	3.25	3.21	0.203	16.15
Fraxinus micrantha Lingelsheim	Oleaceae	4	4	1.00	0.10	0.250	1.53
Juglans regia L.,	Juglandaceae	8	12	1.50	0.48	0.188	4.06
Lyonia ovalifolia (Wallich)	Ericaceae	64	220	3.44	11.23	0.054	58.78
Myrica esculenta. Buch-Ham.ex D.Don	Myricaceae	36	100	2.78	3.70	0.077	23.69
Pinus roxburghii Sargent	Pinaceae	20	68	3.40	3.05	0.170	16.73
Prunus cerosoides D.Don	Rosaceae	4	4	1.00	0.07	0.250	1.40
Pyrus communis L.	Rosaceae	4	12	3.00	0.29	0.750	2.19
Pyrus pashia Buch-Ham.ex D.Don	Rosaceae	20	32	1.60	0.99	0.080	9.35
Quercus leucotrichophora A. Campus.	Fagaceae	88	420	4.77	21.80	0.054	103.54
Rhododendron arboreum Smith	Ericaceae	68	272	4.00	10.15	0.059	56.06
Symplocos ramosissima Roxb**.**	Symplocaceae	12	28	2.33	0.85	0.194	6.53
		-	1222	-	55.92	-	-

Notes: F is Frequency, Ab is Abundance, TBC is Total basal cover (m^{2}· ha^{-1}), A/F Ratio is Abundance to frequency ratio, IVI is Important value Index.

Table 2. Phytosociological analysis of shrubs

Name of shrub	Family	F%	Density (individuals per 25 m^{2})	Ab	A/F ratio	IVI
Daphne papyraceae Wallich ex Steudel,	Thymelaeaceae	18	0.58	3.22	0.18	10.281
Berberis aristata DC.	Berberidaceae	70	2.88	4.11	0.06	45.450
Berberis asiatica Roxb. ex	Berberidaceae	14	0.28	2.00	0.14	6.498
Rubus ellipticus smith	Rubiaceae	8	0.22	2.75	0.34	4.239
Rosa brunonii Lindley	Rosaceae	14	0.32	2.29	0.16	6.848
Rosa macrophylla Lindley	Rosaceae	16	0.16	1.00	0.06	6.025
Pyracantha crenulata(D.Don) M.Roemer	Rosaceae	34	1.14	3.35	0.10	19.809
Smilax aspera L.	Smilacaceae	8	0.12	1.50	0.19	3.363
Debregeaia longifolia Burm. F.	Uritaceae	6	0.12	2.00	0.33	2.785
Prinsepia utilis Royle	Primulaceae	24	0.74	3.08	0.13	13.416
Cyathula tomentosa (Roth) Moq	Amaranthaceae	10	0.3	3.00	0.30	5.517
Colebrookia oppositifolia J.E.Smith	Lamiaceae	26	0.84	3.23	0.12	14.870
Eupatorium adenophorum Sprengel	Asteraceae	34	1.46	4.29	0.13	22.611
Myrisine africana L.	Myrsinaceae	34	1.54	4.53	0.13	23.312
Urtica dioca L.	Urticaceae	6	0.16	2.67	0.44	3.135
Rhus parviflora Roxb.	Anacardiaceae	10	0.1	1.00	0.10	3.766
Lantana camara L.	Verbenaceae	6	0.24	4.00	0.67	3.836
Hypericum elodeoides Choisy	Hypericaceae	2	0.06	3.00	1.50	1.103
		-	11.42	-	-	-

Notes: F is Frequency, Ab is Abundance, A/F Ratio is Abundance to frequency ratio, IVI is Important value Index.

Table 3. Phytosociological analysis of herbs

Name of herb	Family	F%	Density (individuals · m^{-2})	Ab	A/F ratio	IVI
Anaphalis adnata Wallich ex DC	Asteraceae	12	0.59	4.92	0.41	10.96
Anaphalis contorta (D.Don) Hook.f	Asteraceae	11	0.61	5.55	0.50	10.53
Andropogon munroi C.B.Clarke	Poaceae	18	3.18	17.67	0.98	32.40
Apluda mutica L.	Poaceae	7	0.35	5.00	0.71	6.43
Bergenia ciliate (Haworth) Sternb	Saxifragaceae	7	0.25	3.57	0.51	5.74
Bidens bipinnata L.	Betulaceae	4	0.21	5.25	1.31	3.75
Bidens pilosa L.	Betulaceae	3	0.23	7.67	2.56	3.31
Boenninghausenia albiflora (Hook.) Reichb.ex Meisn	Rutaceae	1	0.04	4.00	4.00	0.85
Cymbopogon martini(Roxb.) W.Watson	Poaceae	21	1.35	6.43	0.31	21.39
Cynodon dactylon (L.)Persoon	Poaceae	9	1.57	17.44	1.94	16.06
Datura fastuosa L.	Solanaceae	7	0.22	3.14	0.45	5.53
Drypteris cochleata (Buch-Ham. ex D.Don)C.Chr	Dryopteridaceae	13	1.46	11.23	0.86	17.58
Fragaria nubicola Lindely ex Lacaita	Rosaceae	3	0.06	2.00	0.67	2.13
Origanum vulgare L.	Lamiaceae	4	0.07	1.75	0.44	2.77
Parthenium hysterophorus L.	Asteraceae	11	0.42	3.82	0.35	9.21
Potentilla fulgens Wallich ex Hook	Rosaceae	8	0.24	3.00	0.38	6.24
Primula denticulata Smith	Primulaceae	1	0.04	4.00	4.00	0.85
Rumex hastatus D.Don	Polygonaceae	4	0.12	3.00	0.75	3.12
Senecio nudicaulis Buch-Ham ex D.Don	Asteraceae	3	0.06	2.00	0.67	2.13
Senecio rufinervis DC.	Asteraceae	5	0.23	4.60	0.92	4.46
Smilax aspera L.	Smilicaceae	5	0.23	4.60	0.92	4.46
Themeda arundinacea (Roxb.) Rindely	Poaceae	18	2.85	15.83	0.88	30.10
		-	14.38	-	-	-

Notes: F is Frequency, D is Density ((individuals· m^{-2}), Ab is Abundance, A/F Ratio is Abundance to frequency ratio, IVI is Important value Index.

In case of shrubs, *Berberis aristata* and *Myrsine africana* were dominant and co-dominant species with IVI values of 45.40 and 23.31 respectively. *Berberis aristata* showed the highest frequency (70%), density (2.8 individuals per 25 m^2) and abundance (4.11), followed by *Myrsine africana* with frequency (34%), density (1.54 individuals per 25 m^2) and abundance (4.53). *Hypericum elodeoides* was the least dominant shrub species in the site, with lowest values for IVI (1.10), density (0.06 individuals per 25m^2), abundance (3.0) and frequency (2%). The overall shrub density in this forest was 11.42 individuals per 25 m^2 (Table 2). Shannon index for shrub layer was 2.42 and Simpson index 0.12. Saxena and Singh (1982) also recorded t diversity value for shrub layer from 0.74 to 3.10 in Oak forest of Kumaun Himalaya, Uttarakhand, which is in support to the present value.

Among herb layer, *Andropogon munroi* was dominant species with maximum value for IVI (32.40), followed by *Themeda arundinaceae* with IVI (30.10). *Cymbopogon martini* showed highest frequency (21%), followed by *Andropogon munroi* (18%). *Andropogon munroi* had the highest density (3.18 individuals· m^{-2}), followed by *Themeda arundinacea* (2.85 individuals· m^{-2}). *Andropogon munroi* was again observed with highest abundance (17.67), followed by *Cynodon dactylon* (17.44). *Boenninghausenia albiflora* was least dominant species with lowest IVI (0.85). *Senecio nudicaulis* had the lowest density (0.06 individuals· m^{-2}), (Table 3). The values for Shannon and Simpson index for herb layer were 2.41 and 0.12 respectively. The present values of diversity for herbs are similar to the values reported by (Singh et al. 1984; Pande et al. 2002). The Shannon index value (2.54 to 2.99) reported by Pande et al. (2001) is in support of present study. Simpsons index in present study is supported by (Kumar et al. 2004), who reported values from 0.13 to 0.15 for shrubs and 0.05 to 0.10 for herbs in different sub-tropical forests of Garhwal Himalaya.

Out of 12 tree species, 7 species in seedling stage and 8 species in sapling stage were recorded in the study area. The seedling density (1590 individuals· ha^{-1}) in the present study was lower than values reported by (Kumar et al. 2004) from Garhwal Himalaya. The reason for low regeneration might be trampling and grazing. Van Panchayats are common property resource for whole village. The biotic pressures which play an important role in forest community dynamics (Whitemore 1984) often regulate the recruitment and survival pattern of tree seedlings (Canham et al. 1985). *Quercus leucotrichophora* had maximum value for seedlings density (576 individuals· ha^{-1}) and IVI (99.7), followed by *Lyonia ovalifolia* with 296 seedlings· ha^{-1} and IVI (54.8). Total sapling density was 1564 individuals· ha^{-1} and *Quercus leucotrichophora* had maximum value for saplings density (500 individuals· ha^{-1}) and IVI (89.20), followed by *Rhododendron arboreum* (with 344 saplings · ha^{-1}) and IVI (64.63),

(Table 4).

In the present study, 44.41% species had good regeneration status, 16.66% species had fairly regenerating status and 8.33% species had poor regeneration status, while 33% species were not regenerating at all (Fig. 1).

Table 4. Density (individual· ha^{-1}) and IVI of tree species in the study area

Species	Trees		Saplings		Seedlings		Regeneration Status
	Density	IVI	Density	IVI	Density	IVI	
Quercus leucotrichophora	420	103.54	500	89.20	576	99.7	Good
Lyonia ovalifolia	220	58.78	272	51.40	296	54.8	Good
Symplocos ramosissima	28	6.53	0		0		No
Pyrus pashia	32	9.35	52	12.60	68	18.7	Good
Rhododendron arboreum	272	56.06	344	64.63	272	54.8	Fair
Juglans regia	12	4.06	36	9.62	0		Poor
Pyrus communis	12	2.19	0		0		No
Myrica esculenta	100	23.69	136	28.61	168	39.2	Good
Alnus nepalensis	52	16.15	116	20.71	88	17.6	Fair
Prunus cerosoides	4	1.40	0	-	0	-	No
Fraxinus micrantha	4	1.53	0	-	0	-	No
Pinus roxburghii	68	16.73	108	23.24	124	15.3	Good
	1224		1564		1592		

Notes: IVI is Important value Index.

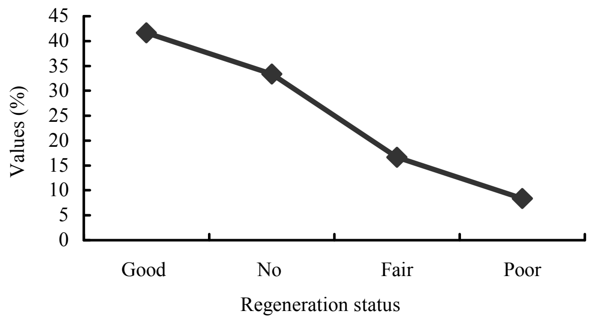

Fig. 1 Regeneration status of tree species

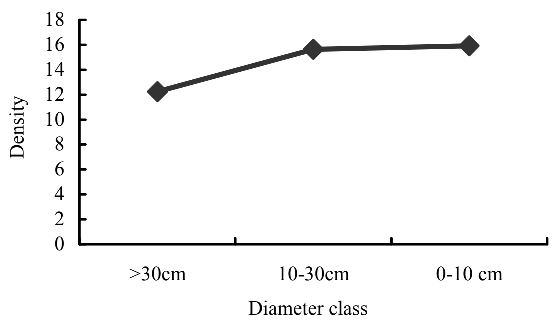

Fig. 2 Density (individual· 100 m^2) and diameter class distribution of trees, sapling and seedlings

The species without seedlings and saplings were *Symplocos ramosissima*, *Pyrus communis*, *Prunus cerasoides* and *Fraxinus micrantha*. The tree species with fair regeneration were *Rhododendron arboreum* and *Alnus nepalensis*. The tree species with good regeneration status were *Quercus leucotrichophora*, *Lyonia ovalifolia*, *Pyrus pashia* and *Myrica esculenta*. Individuals from lower girth classes (0–10 cm and 10–30 cm) showed decreasing distribution trend with the increase in size of girth class (Fig. 2). The number of individuals with small diameter class was greater than the individuals having large diameter in the tree population of Mawphlang in Meghalaya (Khan et al. 1987a).

Conclusion

The study revealed that this forest is rich in floral wealth and is worth for fulfilling the basic livelihood needs of local community in the form of fuelwood, fodder and small timber etc. However, if proper conservation strategies are not formulated in time, there will be some damage to plant diversity within this Van Panchyat. This forest is under severe pressure, due to providing too much sources of energy and feed for livestock and human. It is necessary to give sufficient time to forest to reduce anthropogenic pressure. Therefore, young vegetation will have sufficient time to establish and reach mature stage. The forest needs some silvicultural and management prescription. One of the prescriptions is rotational grazing and extraction i.e. dividing the forest into 4–5 compartments and closing each compartment one by one completely for five years to provide time for vegetation regeneration. Second prescription is enrichment planting in closed compartment with useful species. Effective conservation mechanism for regeneration of important tree species like *Prunus cerasoides*, *Juglans regia* and *Pyrus* species can also be formulated in future.

References

Atkinson ET. 1882. *Gazetteer*, *North West Province: The Himalayan Districts of the North Western Provinces of India*. North Western Provinces: Oudh Government Press, p. 266.

Barik SK, Tripathi RS, Pandey HN, Rao P. 1996. Tree regeneration in a subtropical humid forest: effect of cultural disturbance on seed production, dispersal and germination. *Journal of Applied Ecology*, **33**: 1551-1560.

Berkes F. 2008-Community Conserved Areas: Policy issues in historic and contemporary context. *Conservation Letters*, **2**(1): 20-25.

Canham CD, Marks PL. 1985. The response of woody plants to disturbance patterns of establishment and growth. In: Pickett, S.T.A. and White, P.S. (eds), *The Ecology of Natural Disturbance and Patch Dynamics.*. New York: New York Academic Press, p. 567

Curtis JT, Cottam G. 1956. *Plant Ecology Workbook. Laboratory field reference manual*. Minnesota: Burgers Publication Co, p. 193.

Curtis JT, McIntosh RP. 1950. The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*, **31**: 434-455.

Gaur RD. 1999. *Flora of the district Garhwal North West*. Srinagar (Garhwal)- U.P., India: Transmedia, p. 1-100.

Greig-Smith P. 1957. *Quantitative Plant Ecology*. Butterworth, London: Cambridge University Press, p. 233.

Hannah L, Bowles I. 1995. Letters: global priorities. *Bioscience*, **45**: 122.

Khan ML, Raj JPN, Tripathi RS. 1987a. Regeneration and survival of tree seedlings and sprouts in tropical deciduous and subtropical forests of Meghalaya, India. *Forest Ecology and Management*, **14**: 293-304.

Khan ML, Raj JPN, Tripathi RS. 1987b. Population structure of some tree species in disturbed and protected sub-tropical forests of North East India. *Acta Oecologia*: *Oecologia Applicata*, **8**: 247-255.

Knight DH. 1963. A distance method for constructing forest profile diagrams and obtaining structural data. *Tropical Ecology*, **4**: 89-94.

Kumar M, Joshi M, Todaria NP. 2010. Regeneration status of a sub-tropical *Anogeissus latifolia* forest in Garhwal Himalaya, India. *Journal of Forestry Research*, **21**(4): 439-444.

Kumar M, Rajwar GS, Shrama CM. 2004. Disturbance and dynamics in the subtropical forests of Garhwal Himalaya. *Bulletin of the National Institute of Ecology*, **14**: 43-50.

Kumar M, Sharma CM, Rajwar GS. 2005. The stability and diversity patterns of vegetation in tropical foot hill forest along disturbance gradient in Garhwal Himalaya. *Annals of Forestry*, **13**(1): 84-92.

Negi BS, Chauhan DS, Todaria NP. 2008. Inventory of species richness of panchyats and adjoining reserve forests in three districts of Garhwal Himalaya, India. *Tropical Ecology*, **49**(2): 121-129.

Pande PK, Negi JDS, Sharma SC. 2001. Plant species diversity and vegetation analysis in moist temperate Himalayan forest. *Indian Journal of Forestry*, **24** (4): 456-470.

Pande PK, Negi JDS, Sharma SC. 2002. Plant species diversity, composition, gradient analysis and regeneration behaviour of some tree species in a moist temperate western Himalayan forest ecosystem. *Indian Forester*, **128**(8): 869-889.

Pant GB. 1922. *The forest problems of Kumaun*. Allahabad: Government Press, pp. 40-45

Primack RB, Hall P. 1992. Biodiversity and forest change in Malaysian Borneo. *Bioscience*, **42**: 829-837.

Rawat RS. 2005. Studies on interrelationship of woody vegetation density and soil characteristics along altitudinal gradient in a montane forest of Garhwal Himalays. *Indian Forester*, **131**(8): 990-994.

Richards PW. 1996. *The Tropical Rain Forest: An Ecological Study*. New York: Cambridge University Press, p. 575

Rikhari HC, Singh RS, Tripathi SK. 1991. Pattern of species distribution, community characters and regeneration in major forest communities along an elevational gradient in central Himalaya. *International Journal of Ecology and Environmental Science*, **17**(3): 167-174.

Saxena AK, Singh JS. 1982. A phytosociological analysis of woody species in forest communities of Kumaoun Himalaya. *Vegetatio*, **50**: 3-32.

Shannon CE, Wiener W. 1963. *The Mathematical Theory of Communication*. Urbana: University of Illinois Press, p. 117.

Simpson EH. 1949. Measurement of diversity. *Nature*, **163**: 688.

Singh JS, Yadav PS. 1974. Seasonal variation in composition plant biomass and net primary productivity of tropical grassland at Kurukshetra. India. *Ecology Monograph*, **44**: 351-376.

Taylor AH, Zisheng Q. 1988. Regeneration patterns in old growth *Abies –Betula* forests in the Wolong natural reserve, Sichuan, China. *Journal of Ecology*, **76**: 1204-1218.

Uma Shankar R. 2001. A case of high tree diversity in a Sal (*Shorea robusta*) dominated lowland forest of Eastern Himalaya: Floristic composition, regeneration and conservation. *Current Science*, **81**: 776-786.

Whitemore TC. 1984. Tropical rain forest dynamics and its implications for management. In: Gomez-Pompa, A., Whitemore, T.C. and Hadley, M. (eds), *Rain Forest Regeneration and Management*. Man and Biosphere Series 6. Paris: The Parthenon Publishing Group, p. 457.

Wilson EO. 1985. The biological diversity crises. *Bioscience*, **35**: 700-706.